NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS CONSTRUCTION PROGRAM

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HEARING

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON ARMED SERVICES UNITED STATES SENATE

EIGHTY-THIRD CONGRESS

SECOND SESSION

ON

H. R. 7328

AN ACT TO PROMOTE THE NATIONAL DEFENSE BY AUTHORIZING THE CONSTRUCTION OF AERONAUTICAL RESEARCH FACILITIES BY THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS NECESSARY TO THE EFFECTIVE PROSECUTION OF AERONAUTICAL RESEARCH

MAY 4, 1954

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS CONSTRUCTION PROGRAM

TUESDAY, MAY 4, 1954

UNITED STATES SENATE.
SUBCOMMITTEE ON REAL ESTATE AND MILITARY CONSTRUCTION OF THE COMMITTEE ON ARMED SERVICES,
Washington, D. C.

The subcommittee (consisting of Senators Case, Duff, and Stennis) met, pursuant to notice, at 9:50 a. m., in room 212, Senate Office Building.

Present: Senators Francis Case (chairman of subcommittee presiding), James H. Duff, and John C. Stennis.

Also present: William H. Darden, of the committee staff.

Senator CASE. The committee will come to order.

The principal item on the agenda of the subcommittee this morning is H. R. 7328, a bill to promote the national defense by authorizing the construction of aeronautical research facilities by the National Advisory Committee for Aeronautics.

Without objection, a copy of the letter by which the bill was referred to the subcommittee, and a copy of the bill will be inserted in the record at this point.

(The documents referred to follow:)

MARCH 13, 1954.

Hon. FRANCIS CASE,
United States Senate, Washington, D. C.

DEAR SENATOR CASE: I am writing to request that you serve as chairman of a subcommittee for the consideration of H. R. 7328, a bill to authorize the construction of aeronautical research facilities by the National Advisory Committee for Aeronautics.

Senators Duff and Stennis are being asked to serve as the other members of this subcommittee, the membership of which is the same as the membership of the Subcommittee on Real Estate and Military Construction, because the subject matter of the bill is related to the activities of your subcommittee.

Mr. Darden, of the professional staff, is available to assist in this undertaking.

Sincerely yours,

LEVERETT SALTONSTALL, *Chairman.*

[H. R. 7328, 83d Cong., 2d sess.]

AN ACT, To promote the national defense by authorizing the construction of aeronautical research facilities by the National Advisory Committee for Aeronautics necessary to the effective prosecution of aeronautical research.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That pursuant to subsection (b) of section 1 of Public Law 672, approved August 8, 1950 (50 U. S. C. 151b), the National Advisory Committee for Aeronautics is authorized to undertake additional construction, and to purchase and install additional equipment at the following locations:

Langley Aeronautical Laboratory, Hampton, Virginia: High-speed hydrodynamic facility, $1,220,000.

Ames Aeronautical Laboratory, Moffett Field, California: Alterations to two small supersonic tunnels, $349,000.

Lewis Flight Propulsion Laboratory, Cleveland, Ohio: Alterations to an existing supersonic tunnel, air dryer for propulsion systems laboratory, air heater for altitude test chambers, and rocket engine research facility, $3,431,000.

SEC. 2. Any of the approximate costs enumerated in section 1 of this Act may, in the discretion of the Director of the National Advisory Committee for Aeronautics, be varied upwards 5 per centum to meet unusual cost variations, but the total cost of all work so enumerated shall not exceed $5,000,000.

SEC. 3. There are hereby authorized to be appropriated not to exceed $5,000,000 to accomplish the purposes of this Act.

Passed the House of Representatives March 4, 1954.

Attest:

LYLE O. SNADER, *Clerk.*

Senator CASE. Since the bill containing the appropriations for this construction has passed the House and has been the subject of hearings before the Senate Appropriations Committee, it seems desirable to complete action on the authorization as soon as possible.

The Chair might state that he recalls that over a period of years, the facilities for the National Advisory Committee for Aeronautics were authorized by the making of appropriations. The point was raised some years ago, I think, in appropriations before the House of Representatives, that they were technically subject to a point of order under the House rules, but by one step or another, the improvements that were needed were made, and there has been no blanket authorization for the National Advisory Committee.

This bill seeks to give authorization for certain specific facilities, notably additional construction, the purchasing and installation of additional equipment at certain locations.

Our first witness this morning is Dr. Hugh L. Dryden, Director of the National Advisory Committee for Aeronautics, who has been before the committee on many occasions in the past.

Dr. Dryden, we are glad to have you with us this morning, and you may proceed with your presentation of the justification for the bill.

STATEMENT OF HUGH L. DRYDEN, DIRECTOR, NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS; ACCOMPANIED BY (See Contents) RALPH E. ULMER, BUDGET OFFICER

Dr. DRYDEN. Mr. Chairman, as you have stated, each year we bring before the legislative committees the items relating to construction, including what are comparatively small items for alterations to existing equipment.

The items before you consist largely of modification of facilities to increase their capability, one addition to existing equipment to meet a new need, and finally one new facility. I will discuss each of these very briefly.

The first item is a high-speed hydrodynamic facility at Langley Aeronautical Laboratory at a cost of $1,220,000.

You have read in the magazines about certain new types of airplanes which land on the water on skis. This development and others have greatly increased the performance possibilities of water-based aircraft.

This facility provides for the study of such landing gears at high water speeds up to 150 miles per hour. We studied many ways of making such experiments. The straightforward way would be to

make a towing car on a track, but the cost of a towing car and track for a speed of 150 miles per hour was very large.

We have at Langley Field a landing loads facility used to study the gear for landing on land. This consists of a track, a propulsion gear and an arresting mechanism.

By building alongside of this track a relatively narrow tank to hold water, we can run a light carriage on the same track, use the same propulsion system, the same arresting gear, and make experiments on skis. This is the purpose of this facility.

The next item in the bill is for modifications at the Ames Laboratory, and consists of two projects: One, alteration of a supersonic free-flight tunnel at a cost of $196,000; the other, 10- by 14-inch supersonic tunnel alterations, at $153,000.

These are modifications to increase the capabilities of existing facilities to meet the needs of the advancing speeds of missiles, primarily.

The supersonic free-flight tunnel is a wind tunnel which has a gun pointed in it so that you can shoot a model against the air current, and thus secure relative speeds very much higher than you can get either with the gun alone or with the wind tunnel alone.

The alterations consist of extending the length of the test section and the number of measuring stations so that the stability of missiles can be studied as well as their resistance to motion.

The alteration to the 10- by 14-inch supersonic tunnel is to increase what we call the Reynolds number by increasing the available pressure at which the tunnel can be operated. This has the practical effect of making the results more nearly applicable to full scale.

Both of these items for relatively small cost give us important additions to our capabilities.

I might say, as I think the committee knows, we have a plant with a value exceeding $250 million, and you may expect each year to receive items of this kind where, by relatively small expenditures we are able to meet new needs as they arise.

The next item in the bill groups together four items at the Lewis flight propulsion laboratory at Cleveland, Ohio. The first item—the first three items are modifications of the character I have described. The first one, $120,000, to increase the speed range of the 8- by 6-foot supersonic tunnel; this supersonic tunnel has a speed range from 1.5 to 2 times the speed of sound.

When the tunnel was built, we did not know how to extend the speed range downward, although we wanted to, very much.

Now, it has been found possible—someone has thought up an idea by means of which, for the relatively small expenditure of $120,000 in a facility valued at several millions, we can extend the speed range downward by 60 percent.

The next item is $458,000 for an air drier for the propulsion systems laboratory. This need arises out of our experience during the past year in testing the ram jet engine for one of our missiles. In the course of these tests, we found that it would be necessary to have additional air drying capacity to cover the full range of altitude and speed required in such testing, and therefore we request this additional air-drier capacity, so that we may operate under lower altitude conditions without getting into condensation of moisture.

The next item is $302,000, and is for a similar purpose, an air heater for the altitude test chambers.

Again, without going into all of the detail, it is a question of simulating the flight conditions at high altitudes and supersonic speeds for turbojet engine investigations.

As you have heard many times, when objects move fast through the air, the air compressed ahead of the object becomes heated, so that to simulate the inlet conditions on a turbojet engine at very high supersonic speed, we must heat up the air. This air heater extends the range of our present altitude test chambers.

The final item is a new facility, the only new facility, on the list, a rocket engine research facility at the Lewis Laboratory for $2,551,000.

Senator CASE. Dr. Dryden, before you go into the rocket engine research facilities, let us go back over these different items——

Dr. DRYDEN. Yes.

Senator CASE (continuing). And take up any questions the committee may have with respect thereto. These others are all additions to existing facilities?

Dr. DRYDEN. That is correct.

Senator CASE. First, with respect to the high-speed hydrodynamic facility at Langley——

Dr. DRYDEN. Yes.

Senator CASE (continuing). As I understand it, primarily this is to utilize the modification of jet aircraft over conventional aircraft in developing planes that will be operable on water?

Dr. DRYDEN. On water; yes, sir. You may have seen the picture some months ago in Time and Life of a prototype aircraft developed by Consolidated which operates on skis, and actually can come right up out of the water on the beach. I do not know whether you recall seeing this picture or not, but it is a very promising development for certain military applications.

Senator CASE. Will that also take the place of pontoons?

Dr. DRYDEN. Yes. It performs somewhat the same function. In this case the airplane is made watertight so it floats with its fuselage right down in the water if it is not moving. As the airplane accelerates, it rises out of the water onto the skis.

Senator CASE. It happens that last August 2 members of this committee—the 2 members present, in fact—were in Alaska, and there, going over to Ketchikan and some other places, we went in what they call ducks, or geese, or whatever they call it, but small aircraft using pontoons.

Dr. DRYDEN. Yes.

Senator CASE. Would you suggest that what you seek here is something that would make pontoons usable in an area where you had lakes as common as you do in Alaska or in some other sections?

Dr. DRYDEN. This is the general purpose, and there are other attempts, I should say, to make a ski which will operate on water, on mud, on ice, on grass, and this has been demonstrated on light airplanes.

Senator CASE. Well, is it conceivable that this would have a bearing on our foreign base development in that, if runways were obliterated, you would have jet bombers that would land on water?

Dr. DRYDEN. Yes. Perhaps we should not put this in the record, Mr. Case. I think I can talk about it in a general way; let me try.

Senator CASE. We understand there is one representative of the press here.

Dr. DRYDEN. Let me try it in the general way, without getting into classified matters.

Senator CASE. I might say it seems to me that it is a natural idea that will occur to anybody if you know that you are working in this field——

Dr. DRYDEN. That is right.

Senator CASE (continuing). Because this committee has been inspecting and proposing and acting upon a great many overseas bases, and one question always arises in connection with those: What happens if your base gets knocked out while your planes are in the air? You have got to have an alternate landing place.

Dr. DRYDEN. Let me make what I think is a considered statement. The military value of this type of aircraft is, I think, clear. It has been demonstrated on an aircraft of relatively low weight. Now, when you come to airplanes of greater weight, there are many problems, and really one purpose of this facility is to find out how far we can go in the direction of increasing the lifting capacity of such devices, on the water.

When you get into the question of substituting water-based aircraft for land bases, you get into a controversy nowadays, because of the—what you might call—supply and logistics problem. There is much more to an airbase than a landing strip. You have to have facilities for putting ammunition and guns and bombs in the airplanes, and you must have refueling, so that you get into an argument between the groups who regard the problems of operating with supply ships as being easy to solve, and those who think that they are difficult.

There is no question in my mind as to the military value of airplanes of this type, and they are going to fulfill certain needs. Whether they will extensively replace other types of aircraft, particularly of larger weight, is a question for the future, I think. I do not believe we can decide that now.

Senator CASE. But, looking at the field from the background of your experience, you regard it as essential in our keeping abreast of modern developments——

Dr. DRYDEN. Yes, I do.

Senator CASE (continuing). To have facilities where you can determine the practicable application of——

Dr. DRYDEN. Skis, planing surfaces.

Senator CASE. To landing aircraft.

Dr. DRYDEN. Yes, sir.

Senator CASE. That also, I suppose, would suggest that a new phase of training will be required for pilots to handle craft of that type?

Dr. DRYDEN. I think you are moving just a little faster than the present state of the art warrants. At the present time, research in this area has gone on for, oh, perhaps, 5 or 6 years. The industry has under military contract produced one prototype with which a certain amount of experience is now being gained. There is still some more to be done before you are quite ready to move into large-scale operation and training programs.

Senator CASE. What about friction; you spoke about landing on grass. It seems to me it would have a problem of friction there that—

Dr. DRYDEN. Well, you have undoubtedly read of airplanes landing on their bellies on the ground with comparative small damage. There is friction when you land on the ground.

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Senator CASE. Well, your landing speed with jet aircraft generally runs higher than it does with the conventional type, does it not, or not necessarily?

Dr. DRYDEN. It depends on how they are designed, yes.

Senator CASE. I notice that in the House report on the bill, when it was in the House, there is a breakdown on the different items of the total cost. Is there any objection to including that?

Dr. DRYDEN. None whatever. We can give the reporter a copy of that.

Senator CASE. I think for the purposes of the record, it would be desirable to incorporate the entire breakdown as shown there, taken from your report.

Dr. DRYDEN. May I just make sure? I do not happen to have that before me—yes, this is the justification.

Senator CASE. It gives the cost estimate of the different items.

(The document referred to follows:)

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS—BRIEF JUSTIFICATION FOR FISCAL YEAR 1955 CONSTRUCTION PROJECTS

LANGLEY AERONAUTICAL LABORATORY

High-speed hydrodynamic facility ($1,220,000).—It is proposed to construct a concrete towing basin adjacent to the existing landing-loads track and to utilize the existing track for operation of a new high-speed carriage for research on the landing and takeoff characteristics of high-speed water-based aircraft. Observation stations, a model-preparation shop, offices, and necessary alterations to the existing landing loads track are included. Recent developments in design and handling techniques have shown the possibility of constructing water-based aircraft having performance comparable to that of advanced types of land-based aircraft. Present hydrodynamic research facilities are limited to speeds up to 60 miles per hour, while the needs for design data range up to 150 miles per hour. The most expeditious method for obtaining the necessary new facility is to utilize the equipment of the landing-loads track for propelling and arresting the model, and to build a new towing tank and auxiliary apparatus adjacent to the track. This will make possible the production of design data for the maximum utilization of new principles in the development of water-based military aircraft.

AMES AERONAUTICAL LABORATORY

Supersonic free-flight tunnel alterations ($196,000).—It is proposed to construct a new test section for this facility, increasing its length by 9 feet, and increasing the number of shadowgraph stations from 7 to 18. Research data on drag, lift, pitching moment, damping in roll, aileron effectiveness, boundary-layer transition, and skin friction is required in the development of aircraft and missiles designed to operate at very high Mach numbers. The present tunnel is adequate for the accurate measurement of drag, but has been found to be inadequate for other measurements. The proposed alterations will remedy this defect.

Ten- by 14-inch supersonic tunnel alterations ($153,000).—The purpose of this project is to increase the Reynolds number range of the tunnel by about 200 percent. An existing compressor in the adjacent 10- by 10 inch heat transfer tunnel can be utilized by installing appropriate piping and control equipment, and making some structural alterations. The modified facility will then be capable of determining altitude effects on the aerodynamic characteristics of modern high-speed missiles.

LEWIS FLIGHT PROPULSION LABORATORY

Eight- by six-foot supersonic tunnel alterations ($130,000).—The alterations contemplated under this project consist of changing the upstream connections of the flexible nozzle plates of the test section to permit operation of the tunnel at lower supersonic speeds. The present tunnel speed range, while adequate for presently contemplated combat design speeds, does not permit evaluation of promising designs in the critical low supersonic speed range. The modifications will allow the necessary research data to be obtained quickly and economically.

Air dryer for propulsion systems laboratory (*$458,000*).—The addition of a third air-drying tower and associated refrigeration equipment is proposed under this project. This will make possible the use of the free-jet technique, which requires dry air, in ram and turbojet engine investigations to obtain reliable inlet and engine-matching data.

Air heater for altitude test chambers (*$302,000*).—The proposed project includes the installation of the necessary equipment to heat the combustion air used in two altitude test chambers in the engine-research building. In order to simulate flight conditions at high altitude and supersonic speeds for turbojet engine investigations, inlet air must be provided at elevated temperatures. The installation of the equipment covered by this project is the most economical means of accomplishing this purpose.

Rocket engine research facility (*$2,551,000*).—This proposed new facility includes a test structure with apparatus for the removal and disposal of products of combustion from the rocket exhaust, appropriate instrumentation, fuel storage pits and tanks, a central building containing a shop, instrument center, and offices for the research staff, and necessary utilities. High-energy propellants will be investigated in rocket engines of medium thrust. In the design of rocket-powered vehicles for the military services, many practical problems associated with rocket motor size have been encountered. These problems can only be attacked and solved by conducting research in a facility of this type where motors covering a range of thrust levels and periods of operation can be investigated.

Senator CASE. I should like to ask a question or two about the items. I notice one item for $80,040 for outside utilities, roads, and walks. Will this proposed facility utilize existing utility supplies at Langley?

Dr. DRYDEN. This facility is located remotely from most of the other buildings. I have here a map to show exactly what is involved in the access road to this water tank alongside the landing-loads track.

Senator CASE. You are not contemplating a new utility plant?

Dr. DRYDEN. Oh, no.

Senator CASE. These are just service connections?

Dr. DRYDEN. Just service connections. You see, it is impracticable to put this map in the record. Here is the landing-loads track, and there is the road, alongside it.

Senator CASE. And the heating plant and other utility plants there can handle this additional load without increases?

Dr. DRYDEN. Yes.

Senator CASE. What type of building is the office and shop which is estimated at $398,500?

Dr. DRYDEN. It is a standard——

Senator CASE. Steel construction?

Dr. DRYDEN. It is brick construction.

Senator CASE. Fireproof?

Dr. DRYDEN. Yes, sir.

Senator CASE. Are there further questions? If not, with respect to the items at Ames Laboratory, the supersonic free-flight tunnel alterations is what we will take up next.

I will ask a question here that will be applicable to the others. How will this work be accomplished, by competitive bids?

Mr. ULMER. Yes; for the most part.

Senator CASE. You say for the most part; do you have authority for so-called force account or purchase and hire?

Mr. ULMER. Occasionally we have to negotiate a contract where it is impossible to secure competition, but the great percentage of contracts will be advertised and awarded to the lowest bidder.

Senator CASE. Are there any of these items in the entire proposal today that require screened personnel because of security reasons for the construction of these?

Dr. DRYDEN. Not for the construction; no, sir. All of our people are screened for security in operations.

Senator CASE. But during the period of construction there is no screening?

Dr. DRYDEN. There is nothing confidential about it.

May I ask, to be sure, Mr. Chairman, that you wish that material to be put in the record?

Senator CASE. Yes, I think so; we would have it for reference.

Dr. DRYDEN. I just wanted to understand it.

Senator CASE. That will be available for the Senate floor, if they desire it.

Turning now to the Lewis Flight Propulsion Laboratory, the 8- by 6-foot supersonic tunnel alteration, I do not quite understand what you meant by adjustments downward.

Dr. DRYDEN. In speed, in the speed of the tunnel. In a supersonic tunnel, the speed can only be changed by changing the cross section of the tunnel. This is ordinarily done by having flexible plates whose shape is changed. These flexible plates on a large tunnel are relatively thick, and they can be bent only so much without getting an undue strain.

The idea which has come up, which the people have come up with to be able to get a greater change in shape, is by moving one of the support points of this plate rather than bending it further so as to open up the cross section which, in a supersonic tunnel permits lower airspeed.

Senator CASE. Then, as to the air drier for propulsion systems laboratory, why would you say that this is an essential improvement at this time?

Dr. DRYDEN. I think I mentioned that this grew out of our experience in working with engines which are now under development. A technique has been developed of testing these engines to simulate the air inlet conditions, and in the tests which we have run we have found the velocity limited by the condensation of water, moisture, that is normally present in the air.

When the facility was built, we put in the drier capacity that was thought to be needed in the state of our knowledge at that time. Since actually running tests on engines, we find that it is necessary to increase the drying capacity somewhat to reach the altitude and speed conditions corresponding to the missiles which are now under development.

Senator CASE. I was intrigued a little bit by the sentence in your statement in the annual report which says:

> At supersonic air velocities the condensation of water vapor from the air occurs as it leaves the nozzle of the test facility.

The condensation of water vapor always intrigues me a bit because of the testimony I heard with reference to cloud modification, the research that is going on in that field now.

We have recently set up a Weather Advisory Commission to work in that field. It is possible that your research in this field, in the study of condensation of water vapors under various conditions might be of interest to the Commission on cloud modification.

Dr. DRYDEN. The underlying process is the same. I do not know that our experience can be directly applied.

You see, in order to get a high speed, all you do is take air at high pressure and expand it to a lower pressure. When you expand it to a low pressure it cools very much, and it is this cooling which causes the water to condense. The experiments do give certain information on the phenomena, for example, condensation occurs earlier if you have dust particles or nuclei in the room, but the only way which laboratory people have found to deal with it is to heat up the air at high pressure to a higher temperature so that after expansion it does not cool down quite so much. If, of course, you go high enough, of course, the air itself condenses, and the same thing——

Senator CASE. The same thing is happening on this glass there. When we have ice in our water here, we get condensation of water on the outside of the glass, and when we do not put ice in it, we do not.

Dr. DRYDEN. That is because the expansion cools the air just like the ice cools the water, so the moisture condenses.

Senator CASE. Your reference to dust particles in the air reminds me of the time when Dr. Bowen, who is an Australian scientist, was here recently to lecture before the Weather Bureau, and he said in Australia they have been making some studies which tend to indicate that they get an increase in rain there when that part of the hemisphere passes through a certain meteoric dust, which is the residue of some comet or some planet, planetary disturbance.

Dr. DRYDEN. I have read of his work, although I did not hear his lecture.

Senator CASE. But that seemed to be related to this whole problem, and the condensation of moisture in cooling is what these people are studying when they are talking about cloud modification.

I think that while there seems to be here a specific application and the field seems somewhat unrelated, I think it would be of interest to the scientific field to see what you achieve here.

Dr. DRYDEN. Well, there are several papers by our own scientists, and scientists in universities on this problem in which the observed results are compared with certain theories of condensation as to the growth of water droplets, and the rate of evaporation of water droplets, so that the information, I think, is of interest, of fundamental scientific interest.

Senator CASE. I do not want to be held to the figures exactly, but it seems to me I remember hearing testimony that the introduction of silver iodide into clouds is supposed to reduce from a $-30°$ to a $-5°$ C. the point at which ice could be formed.

Dr. DRYDEN. Yes.

Senator CASE. So that there must be some relationship in the information that you get here.

Dr. DRYDEN. Yes.

Senator CASE. It might be of considerable interest to those people, too.

While I think it is the function primarily of the Appropriations Committee under an authorization of this sort to go into these different items of costs, it would be interesting for the record to know how you arrive at estimating these considerations of the cost.

I notice you have odd amounts here of $420, and in your total it works out to $2,551,000, and so forth. Those must be more or less arbitrary, but——

Dr. DRYDEN. They are based on experience. I would rather let our Budget Officer talk about details. We, of course, have been in this kind of thing now for something—the committee has, not myself personally—ever since it began in 1915, so that there is a very large background of experience, and we have had some construction, I think, almost every year.

Mr. ULMER. That is right.

Senator CASE. In these fields?

Dr. DRYDEN. In these fields.

Senator CASE. So there is some experience factor.

Mr. ULMER. A great deal of experience; yes, sir.

Senator CASE. Let us take up—pardon me, are there further questions?

Senator STENNIS. No; nothing further.

Senator CASE. The final item is the new item, the rocket engine research facility. Will you, Dr. Dryden, state the urgency and the need for it.

Dr. DRYDEN. I might state first what it is all about. This facility is necessary if we are to exercise our responsibilities in connection with the ultimate development of very long range missiles.

I, of course, will not go into the projects that are underway or the state of development or anything of that sort. The facility is designed to study the performance of special fuels which I would rather not put in the record at this point.

As you know, the present most common fuel combination for large rockets is liquid oxygen and alcohol. This was the fuel of the V–2. We have done work on a relatively small scale on special fuels which show great promise. They could be applied by a designer either to reduce very greatly the size of the missile to go a certain range, or they could be applied to give a greater range to a missile of the same weight; in other words, the designer can apply a scientific result in various ways.

I mentioned that we have at the present time small-scale facilities for work on rocket fuels, on the stability of the combustion of rockets. One problem with all rockets is to get the fuels to burn steadily without very large pulsations which not only reduce the efficiency, but also sometimes destroy the rocket itself. We have also studied on a small scale cooling problems connected with the construction of rockets.

As you know, the temperatures of combustion are so high that we do not know any material that would stand these temperatures, and the engineer who designs the rocket cools it just as you cool your automobile engine, except he is operating at a higher temperature level.

These facilities give results which point the way toward practical development, but are not of sufficient scale to furnish a sound foundation to a designer. He cannot have confidence in something made with a small rocket like this to go ahead with the design of a very large rocket such as some of these missiles require.

I should like to make very clear that it is not the business of the NACA to design rockets; it is not the business of the NACA to evaluate rocketmaking experiments such as go on at the very large installations that you may have visited at the North American Co., or at the Edwards Air Force Base.

Our job is a research job, and the particular areas are the behavior of fuels, the steadiness of their combustion, and the cooling problems.

Senator CASE. The fact, however, that the Navy and the Army and the Air Force have all done work in related fields would suggest that there must have been some research prior to whatever development they have engaged in. Who did the research for them?

Dr. DRYDEN. A great deal of research is conducted in connection with developments on things which we now have. The research which is done in connection with the development is aimed at a very specific military requirement; I mean the company is given specifications for a rocket of a certain range to carry a certain payload, and the industry job is to produce that piece of hardware.

Now if the company feels that all the answers are not available to them from research, if research has not been done in time, then the company has to divert some of its effort from the design of this particular rocket for the military to solve the problems which they get into, usually because of some trouble that——

Senator CASE. Is there any private or public facility in existence in the United States today which provides the opportunity for research along the lines you have indicated for this particular facility?

Dr. DRYDEN. No, there is none. This has been discussed with the groups in the Department of Defense, the various coordinating committees in the Department of Defense; there is no facility which studies these special fuels, and I might say that a considerable part of the cost of this facility relates to the handling of the special fuels.

They are chemicals which have properties that make it necessary to take proper precautions in dealing with them.

One of them, perhaps, will be manufactured at the site.

Senator CASE. Of course, the question of overlapping of research facilities is one which has been threshed over by you before many congressional committees.

Dr. DRYDEN. Many times; that is right.

Senator CASE. You have referred to certain coordinating committees within the executive branch. Will you state what they are?

Dr. DRYDEN. These are the facilities committee—this was first discussed in the facilities committee under the Research and Development Board of the Department of Defense.

As you know, the Research and Development Board was abolished in the reorganization of the Department of Defense, and its duties were reassigned to the Office of the Assistant Secretary of Defense for Research and Development, and it is this group that I am speaking of.

Senator CASE. Does this particular project have the endorsement of Dr. Quarles?

Dr. DRYDEN. I do not have a specific letter. Dr. Quarles is a member of the National Advisory Committee for Aeronautics, but was not a member when the budget was prepared. Military members participated in the discussion of this in the executive committee of the NACA. They voted for it as members of the National Advisory Committee for Aeronautics.

Senator CASE. Has this been cleared with the coordinating committees?

Dr. DRYDEN. I think—we have no mechanism for formal clearance of having one Government agency pass specifically on the budget requests of another Government agency. It has been discussed——

Senator CASE. What did you mean, then, when you referred to the coordinating committees with reference to this?

Dr. DRYDEN. These are the committees who internally coordinate the projects of the Department of Defense, and we have a working relationship with them in that I or some member of my staff holds membership on the internal coordinating committees of the Department of Defense, and Mr. Quarles will—he has not been on NACA long enough to serve as yet on our facilities panel in discussing these things, but he is a member of the facilities panel of the National Advisory Committee.

Senator CASE. As you have stated the need or the field for such a facility, it seems attractive to me, but you have referred to coordinating committees, and yet you have not yet for the record specifically said that the coordinating committees have assigned this particular task to the NACA.

Dr. DRYDEN. No.

Senator CASE. You said there is no other existing facility, but I would like to have the record show——

Dr. DRYDEN. That it fills the need—I, perhaps, can state the problem this way: The NACA does not take the budget of the Department of Defense on public works, and say, "We approve these items," nor do they take ours.

Senator CASE. What I would like to find out for the record, if I can get it there in some way, is not your statement that there is no existing facilities like this, but either through the coordinating committees, or some other authentic knowledge you are able to say that this particular field is not going to be occupied by the research carried on by the Air Force of the Navy or the Army or some other group.

Dr. DRYDEN. I can say that because the plans of both of us have been discussed in both groups, we see that there is no duplication in this area. I cannot say that there has been a formal vote of the Defense Department or that we have voted on any of the Department of Defense facilities.

Senator CASE. So there is neither an existing nor prospective occupancy of this field by any other agency?

Dr. DRYDEN. That is correct. If I might make one remark about the relative state of research and development: We have presented to the Appropriations Committee of the House many times the point of view that the research, as far as NACA is concerned, the basic research, the research not tied up with a specific missile, airplane, or engine, is out of balance with the development.

The NACA level has been held at a fixed amount while the amount of money devoted to hardware development by the military has been multiplied by 2 or 3.

Now, this is a very dangerous subject to discuss before the press.

The developments cannot wait until all research is finished, otherwise we could get no developments at all. On the other hand, if we rush into developments without having an adequate background of research, we are going to spend a lot of money finding out in a very expensive way and on a large scale that certain things do not work.

Now, what is needed is a balance; you cannot wait until all research is finished before you go ahead with radical development.

Senator CASE. We have model T's, or model A's, as you go along.

Dr. DRYDEN. You have to balance the two. We have argued that the thing is not quite in balance. This does not convey any idea that we feel that the military is wasting money by going ahead with devel-

opments, but we think that there would be an overall economy to the Government with a little more effort in exploring such avenues as the use of new fuels before we make some development project to go ahead and use these fuels. I hope the press would reflect this properly.

It is not a criticism of anything that has been done. We did not wait until we had all the research done before we decided to try to go ahead and develop an atomic bomb. We put a big effort in it; we also carried on research simultaneously. The job could have been done cheaper if we had had time to do the research first and then do the development, but we do not have the time in these military things.

Now, I do not want to bring this matter up in this committee because it is not pertinent to your work. We have explored this enough with the Appropriations Committee, and I must say we have not convinced certain individuals as yet on that committee, but this is the way we feel about it.

As you know, in these facility matters you have to literally look years ahead. We started discussing this, perhaps, 2 years ago internally with the Department of Defense. It comes to Congress this year. We may get this this year; it takes another year, I have forgotten the estimate on this—something around 2 years to build this before it is in operation. It then takes a year or two of work before you have something which goes into hardware, so this is looking ahead. This is not something which will affect something which we are building next year or the year after, but this is what you have to do, you have to anticipate facility needs long ahead of the time that you have to have them.

Senator CASE. I have complete sympathy with the purpose of trying to keep research far enough in advance so that what we produce is not too—or is not obsolete at the time that it is produced.

Senator DUFF. In other words, relative proportions are what you are aiming at?

Dr. DRYDEN. That is correct.

Senator CASE. Are there further questions?

Did you have any other witnesses you wanted to present?

Dr. DRYDEN. No, sir.

Senator CASE. Thank you very much.

The committee will consider the bill later.

Is there any objection to reporting the bill favorably to the full committee? If not, the clerk will prepare a report for the full committee, favorably reporting on H. R. 7328.

(Whereupon, at 10:30 a. m., the committee adjourned, to go into executive session.)